ONR Graduate Traineeship Award Update

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LONG-TERM GOALS

The top-level goal of this project is to examine the physics of ambient noise in the ocean which limits the use of ambient noise correlation techniques. In addition this research should lead the PI to a Ph.D.

OBJECTIVES

Noise correlation processing extracts coherent signals from seemingly random noise data. Although this technique has been successfully used in processing ocean ambient noise data it has severe limitations due to the changing ocean environment and the spactial and temporal variability in sources. In this project we are: (1) investigating the physics of the noise processing procedure that constrains the optimum correlation, (2) attempting to understand where and how the degradation of the derived time domain Green's function (TDGF) comes about, and (3) exploit array and signal processing techniques to optimmize the signal-to-clutter (otherwise known as the 'signal-to-noise') rate of the noise correlation processing.

APPROACH

Using both computer simulations, Monte Carlo noise simulations, and ambient noise ocean data I have continued analyzing the noise correlation processing techniques already in use. In addition, I have now begun adapting standard signal processing techniques (e.g. beamforming) to the noise correlation on a horizontal array. The data set used is from the Adaptive Beach Monitoring (ABM) experiment in 1995. The simulation is of the same ocean environment so the comparison between the results is easy.

This work was greatly aided by my advisor, Professor William Kuperman, and Prof. Karim Sabra (formerly of MPL, now at Georgia Tech). Prof. Sabra had previously laid much of the groundwork for this research and allowed me to build upon his suite of noise processing models.

WORK COMPLETED

Building upon last year's work, this past year I created a Monte Carlo noise model of the environment to compare with the ABM noise data. This model, when processed with the same noise correlation techniques, matched up with both the processed ambient noise data and the simulation of the Green's function for the same environment. This led to a better understanding of which characteristics of the environment could be extracted from the correlation processing on the horizontal array, specifically finding the critical angle between the water and sediment layers from the relative strengths of the surface reflections.

Report Documentation Page

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14. ABSTRACT
The top-level goal of this project is to examine the physics of ambient noise in the ocean which limits the use of ambient noise correlation techniques.

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RESULTS

This project has shown that the noise correlation processing of the ocean ambient noise data accurately matches both a Green's function simulation of the same ocean environment and the same processing of a Monte Carlo noise model. In addition, specific details about the environment can be determined from close examination of the approximate Green's function produced from the noise correlation processing.

A comparison of the noise correlation processed ABM data with the identically processed Monte Carlo noise model simulation and the theoretical time domain Green's function for the same environment is shown in figure 1. The time of arrival information is in agreement for all three cases. The noise correlation processed Monte Carlo noise model here shows a weaker surface reflection return. This is due to the distribution of sources chosen for the model – the more vertically distributed the sources the stronger the surface reflection path can become, while as to track the direct path as accurately as possible the sources had to be localized along the bottom of water column.

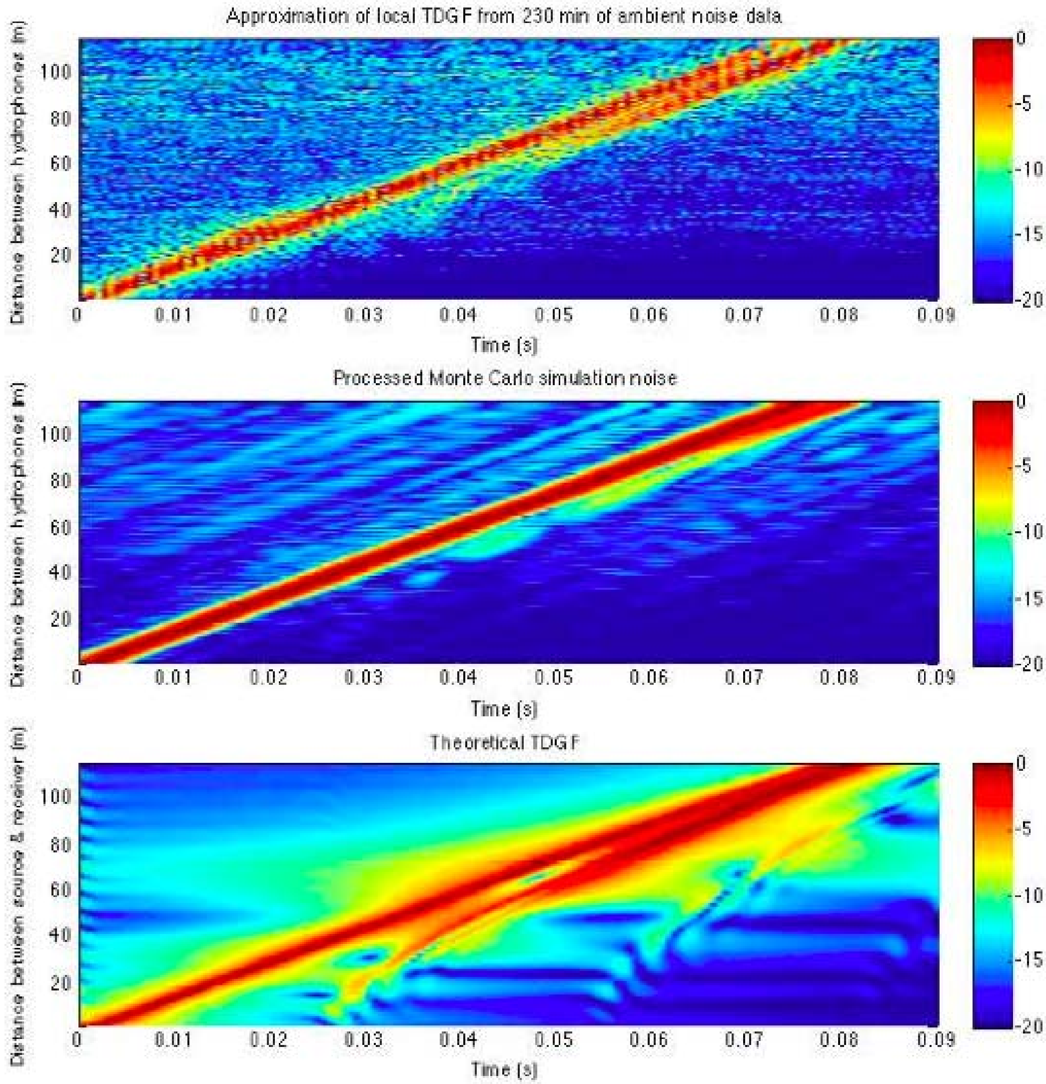

Figure 1: Comparison of the approximate Green's function produced from the noise correlation proceessing of the ABM ambient noise data (top plot) with the same processing of the Monte Carlo noise model simulated noise (middle plot) and the simulated time domain Green's function (bottom plot) for the same environment. Each plot has time in the x-axis and distance in the y-axis, and the colorscale is normalized dB. The red lines give the arrival times for the paths between hydrophone pairs' direct and surface reflection paths

Isolating the relative strengths of the surface reflection path return and plotting these by the angle of reflection procudes a curve strongly reminiscent of the curve of calculated reflection coefficients. Examination of this curve, shown in figure 2, shows that it accurately points to the critical angle between the water and sediments.

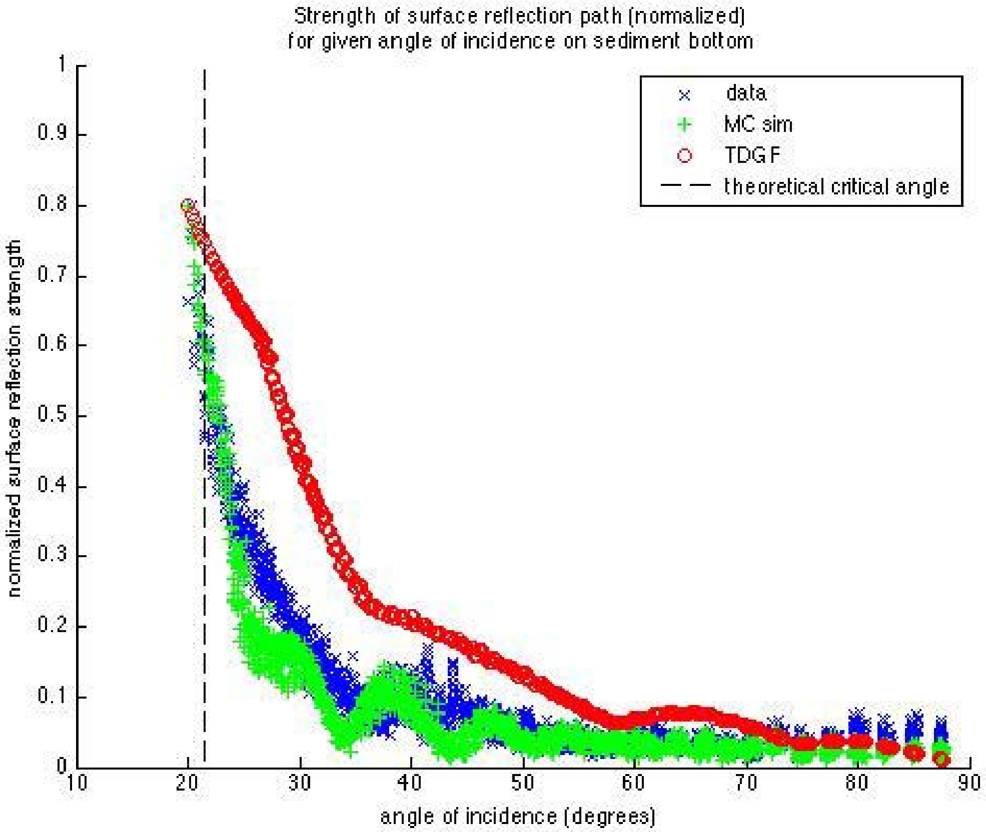

Figure 2: Strength of the surface reflection raypath return by theoretical angle of incidence on sediment floor (x axis) for processed data (blue x's), Monte Carlo noise simulations (green +'s), and the simulated TDGF between two points (red o's). The strength of the return was normalized by the surface reflection path length (to engate 1/R spherical spreadding) and normalized. Reflection strength cure indicated a critical angle of just over 20 degrees which agrees with the theoretical critical angle (dotted black line) given the measured environment.

IMPACT/APPLICATIONS

Potential future impact for Science and/or Systems Applications is that it finds application for noise, typically rejected and not further used.

RELATED PROJECTS

This research is related to the ONR 6.1 program "Extracting Coherent Structures from High Frequency Ocean Noise."

PUBLICATIONS

S. E. Fried, K. G. Sabra, P. Roux and W. A. Kuperman, "Extracting the local Green's function on a horizontal array from ambient ocean noise," J. Acoust. Soc. Am. **124** El 183-188 (2008). [in press]